3rd Conference of the

International Carnivorous Plant Society

16-18 June 2000

San Francisco, USA

In cooperation with the

Northern California Carnivorous Plant Society

Proceedings

Edited by David Gray, Barry Meyers-Rice, and Jan Schlauer
Desktop Layout by Steve Baker

ICPS Conference Photography Contest Winners

1. Best Carnivorous Plant in Habitat
   Ch'ien Lee—"*Nepenthes pectinata* in habitat"
2. Best Carnivorous Plant in Cultivation
   David Ahrens—"*Sarracenia flava* colony"
3. Best Close-up or Macrophotography/Microphotography
   John Brittnacher—"*Sarracenia alata*"
4. Best Insect/Animal Interaction
   Thomas Carow—"Mother spider with offspring on *Nepenthes tobaica* pitcher"
5. Best Original Art
   Eric Schlosser—"Manipulated close-up of *Utricularia alpina* flower"
6. Best Photo of Carnivorous Plant Person/People, or Plant and Person Interaction
   Ch'ien Lee—"Woman using *Nepenthes ampullaria* for a cooking vessel"
7. Uncategorized—changed to: Judge's Favorite of Show
   Barry's: Ch'ien Lee—"Woman using *Nepenthes ampullaria* for a cooking vessel"
   David's: Ch'ien Lee—"*Nepenthes ampullaria* in habitat"
   Bill's: Ch'ien Lee—"*Nepenthes pectinata* in habitat"

And Honorable mentions for:
—Rarest/Most Beautiful Species or Cultivar
   Ch'ien Lee—"Woman using *Nepenthes ampullaria* for a cooking vessel"
—Best Photograph from a Person Under 16
   Matt Martinez—"*Sarracenia leucophylla*"
—Funniest Photo/Original Art
   Tina Kessler—"Fisheye Lens Photograph of *Sarracenia flava*"

The ICPS photo contest was judged by David Gray (Conference Organizer), Barry Meyers-Rice (CPN editor), and Bill Weaver (photographer). The photo titles used on this page are descriptive, and are not necessarily the same used by the photographer.

Introduction by the Conference Organizer

I am so glad everyone who has written about the ICPS World Conference in San Francisco enjoyed it. I am very happy that we were able to bring so many people from around the world to meet in San Francisco and share their knowledge on carnivorous plants. I am proud that the ICPS has some new directions for the future that came out of discussions that began at the conference; conversations about ways of better serving the members, new questions for research, and many conservation strategies and initiatives. I am pleased to be serving with the International Society to move these ideas forward in the coming years.

The conference was a success as a direct result of the great support it received from a great number of people, but a few should be mentioned in particular. Cindy Slezak deserves a huge thank you from all of us, and so do some volunteers who performed above and beyond the call of duty—Margaret Boomer, Katherine Henwood, Bill Weaver, Stephanie Van Parys, and Judith Finn spring first to my mind. They all missed parts of the conference to help in various ways. Barry Meyers-Rice, Madeleine Groves, and the board members of the ICPS all provided key support. Thanks also to the Bay Area Carnivorous Plant Society, and all of you who volunteered in organizing the event.

We must recognize and thank the generous people who donated plants and other items for the auction, and those who donated directly to the organizing effort. Many individuals and nurseries donated rare plants, books, botanical prints, and memorabilia. While the list of donors was sadly lost, it should be said that there were at least 23 people who donated over $100 dollars worth of items. All these donations were a saving grace, and helped prevent large financial losses. Thank you each and all.

The largest thanks goes to the speakers, without whom there would have been no conference; you were amazingly great. Many of you came great distances at your own expense to participate, and many contributed their fees back to the conference. Everyone learned and gained from your presentations.

Those who were there know that the fledgling photo contest came off well; you can expect to see some of the excellent winning photos in future issues of Carnivorous Plant Newsletter (see the inside cover of this proceedings for the list of winners). The vendors who brought interesting and new plants were a welcome feature; more than a few conference-goers took home new carnivorous treasures. I am sure everyone enjoyed the chance to socialize at the banquet and enjoy the great food. I will never forget the experience of being entertained with all my new friends by Barry's antics in the featured presentation.

Thanks again to everyone who participated in the ICPS World Conference; to those of you who did not—be sure to start saving for the next one. I know I will not miss it, in fact I can hardly wait!

As always,
Cheers,
David O. Gray

Conference Schedule

Friday June 16
07:30-09:00 Registration/Check in
09:00-09:30 Welcome comments

Session I
09:30-10:30 Katsuhiko Kondo (Japan), Finding and Visualizing Some Unknown Natural Phenomena in Carnivorous Plants by Tissue Culture
10:30-11:30 Charles Clarke (Hong Kong), *Nepenthes* in Sumatra and Peninsular Malaysia
11:30-12:30 Ch'ien Lee (Malaysia), Recent *Nepenthes* Discoveries

Lunch Break/Impromptu Presentations

Session II
14:00-15:00 Robert Cantley (Sri Lanka), *Nepenthes* of the Philippines, Part I
15:00-16:00 Robert Cantley (Sri Lanka), *Nepenthes* of the Philippines, Part II
16:00-17:00 Douglas Darnowski (Maryland), Four Investigations of Carnivorous Plants and Triggerplants
17:00-18:00 Jan Schlauer (Germany), *Triphyophyllum peltatum* (Dioncophyllaceae)—Cultivating a Clandestine Carnivore

Saturday June 17
Session III
08:30-09:30 Joachim Nertz (Germany), The Lost World of Venezuela: Some Observations on Carnivorous Plants in the Guyana Highlands
09:30-10:30 Hawkeye Rondeau (USA), Carnivorous Plants of the West
10:30-11:30 Robert Gibson (Australia), A Carnivorous Plant Tour of New Caledonia, Australia and South Africa, Part I
11:30-12:30 Robert Gibson (Australia), A Carnivorous Plant Tour of New Caledonia, Australia and South Africa, Part II

Lunch Break/Impromptu Presentations

Session IV

14:00-15:00 Teresa A. Golembiewski (USA), A New Carnivorous Plant Course for Young People

15:00-16:00 Barry Meyers-Rice (USA), Invaders vs. the Carnivores: Invasive Species and Carnivorous Plants

16:00-17:00 Laurent Legendre (France), Mechanisms of Trap Closure in *Dionaea muscipula*

17:00-18:00 Laurent Legendre (France), Carnivorous Plants of New Caledonia

18:00-19:30 Break

19:30-22:30 Buffet Banquet, with auction and talk, "Flesh, Plants that Feed, and Human Desires for Both"

Sunday June 18

Session V

09:30-10:30 Chris Frazier (USA), Pollination and Reproductive Ecology of Three Lowland Tropical Pitcher Plants (*Nepenthes*) and Their Hybrids

10:30-11:30 Madeleine Groves (U.K), The Conservation of Three Federally Endangered *Sarracenia* by the Atlanta Botanical Garden

11:30-12:30 Hieko Rischer (Germany), Secondary Metabolism of *Triphyophyllum peltatum*

Lunch Break/Impromptu Presentations

Session VI

14:00-15:00 Herbert C. Kesler (USA), Effects of Light on a Carnivorous Plant, *Drosera capillaris*

Session VII

15:00-18:00 Workshop/Roundtables

Bogs and Terrariums

Kitchen-Table Tissue Culture

Propagation and Tissue Culture

Finding and Visualizing Some Unknown Natural Phenomena in Carnivorous Plants by Tissue Culture

Katsuhiko Kondo[1], Yoshikazu Hoshi[1], Sayuri Ichiishi[2], Tsukasa Iwashina[3], Hiroshi Kajita[1], Yusuke Kondo[2], Toshiharu Nagamitsu[2], Norikazu Tagashira[1]

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[2]Plant Bio-technology Section • Sanmei Electric Co., Ltd.

[3]Tsukuba Botanical Garden • National Science Museum

During the courses of plant tissue cultures in our Laboratory, we have found some unknown, peculiar phenomena especially in organogenesis and morphogenesis, new secondary metabolites, purified clone materials for DNA analyses, and so on. For instance on organogenesis and morphogenesis, if plants of *Drosera ordensis* in the *D. petiolaris* complex cultured *in vitro* were cut longitudinally a half by a razor blade and were continuously cultured *in vitro*, they generated and recovered the other side being surprisingly *D. petiolaris*. The mechanism of this morphogenesis change has been unknown and is expected to be clarified. *Drosera ordensis* and *D. petiolaris* may be taxonomically placed in the same species or category.

The second instance is in the cultured *Drosera peltata* and many other tuberous species of the genus: Top-tips of the plant shoots often produced white or sometimes green color globular-shaped tubers or sometimes elongated ones with many scales on air. Thus, tuberous species of the genus seemed not to respond to the force of gravity and to have basically top and bottom of their shoots mixed up. This phenomenon suggests us new ideas on origin and organogeneses of shoots.

Thirdly, fasciation of *Drosera* may be another interesting phenomenon in tissue culture. Fasciation may be caused by mycoplasma or a recessive single gene or malformation. Induction and maintenance of fasciation by specific culture media may build up new breeding lines. These phenomena suggest us new ideas on origin and organogeneses of shoots.

Tissue-cultured shoot primordia were induced in *Utricularia* to analyze relationships of their underdeveloped organs, very peculiar organization of its vegetative organs that is quite different from those of other flowering plants; each of the vegetative structures in *Utricularia* can grow continuously and transform into any of the other vegetative structures and adventitious buds can appear on all of these vegetative structures. Since these differentiations can be correlated with differences in water qualities in habitats, *Utricularia* can be cultured in a closed, well-controlled microenvironment *in vitro* to study the relationship between organogenesis and spe-

cific chemical components of the medium. These data would also contribute to a satisfactory systematic treatment. NO_3^- (as in KNO_3) and BAP regulation system could control organogenesis in the tissue-cultured shoot primordia of *Utricularia praelonga*. Determination from the tissue cultured shoot primordia to the meristemoids may be triggered and controlled not by phytohormone but by the nitrogen source and subsequently that from the meristemoids to further meristemoid development may be promoted by phytohormone.

On the other hand, effects of macro-components and sucrose in the medium were studied on *in vitro* red-color pigmentation in *Dionaea muscipula* and *Drosera spatulata*. *Dionaea* and *Drosera spatulata* grow commonly in relatively closed ecosystem where the soil is poor in nutrient substances, wet and acid. A great question had remained for a long time why: why do the vegetative structures in *Dionaea*, *Drosera* (and many other carnivorous plants) have different colors in different natural habitats, and is this significant? There are reddish plants, greenish plants and intermediate plants. However, if they are cultivated in pots, they often change color in leaf. Moreover, if they are fed with certain nitrogen-concentrated fertilizers, they also change color in leaf and sometimes die.

Modified 1/2 MS media with less or no macro-element and with more sucrose induced red-color pigmentation in the inner surface of trap lobe in *Dionaea muscipula* and in the glandular hair in *Drosera spatulata* and furthermore in the whole leaves of the both species after four months culture. However, they made plant growth worse. In contrast, 1/2 MS media with more to complete macroelements promoted deeper green colored in the whole plant bodies and larger growth and more proliferation in the both species. HPLC profiled anthocyanins in red colored *Dionaea muscipula* and *Drosera spatulata* grown in 1/2 MS medium with no macro-component and supplemented with 1.5% sucrose at pH 5.6:

1. Delphinidin 3-*O*-glucoside in *Dionaea*.
2. Cyanidin 3-*O*-glucoside (chrysanthemin) in *Dionaea*.
3. Cyanidin 3,5-di-*O*-glucoside (cyanin) in *Drosera spatulata*.
4. Cyanidin 3-*O*-galactoside in *Drosera spatulata*.
5. Cyanidin 3-*O*-glucoside in *Drosera spatulata*.
6. Pelargonidin 3-*O*-galactoside in *Drosera spatulata*.
7. Pelargonidin 3-*O*-glucoside (callistephin) in *Drosera spatulata*.

Delphinidin 3-*O*-glucoside was reported in *Dionaea* by us for the first time, while the other one was already known in the species. All of the anthocyanins found here in *Drosera spatulata* have already been reported in other species of the genus. The anthocyanin pigmentation in the two species may be biosensitive to nitrogen uptake.

Nepenthes in Sumatra and Peninsular Malaysia

Charles Clarke
Hong-Kong • China

With the exception of Borneo, the island of Sumatra is home to more species of *Nepenthes* than anywhere else. Despite this, many species are only known from a small number of herbarium specimens and, global taxonomic treatments notwithstanding, most of them have never been studied in detail. Against this background, the *Nepenthes* of Sumatra and Peninsular Malaysia project was conceived in late 1997. Two and a half years and 20 field expeditions later, it is nearing completion. The obstacles encountered while writing about the *Nepenthes* of Sumatra and Peninsular Malaysia have been many and varied, and not all were easily overcome. Ecological information is scant and the taxonomy of several taxa is confused. A severe drought in 1997, coupled with political unrest in 1998 and 1999 threatened to delay the project indefinitely.

Fortunately, none of these problems proved insurmountable and all of the important regions for *Nepenthes* in Sumatra and Peninsular Malaysia were visited, many of them more than once. Although the final result is the most comprehensively researched account yet published for the *Nepenthes* of Sumatra, it is clear that much work remains to be done, both taxonomic and ecological. Many Sumatran *Nepenthes* are still not adequately represented in herbaria and until more comprehensive collections can be made, there can be little progress in determining their status and relationships with other taxa. Our knowledge of these plants' ecology lags well behind that for the Nepenthes of Borneo, and the logistical difficulties inherent in this research mean that this situation is likely to prevail for the foreseeable future. It is therefore hoped that *Nepenthes* of Sumatra & Peninsular Malaysia will be seen as a first, tentative step towards redressing this situation.

Nepenthes of the Philippines—Part 1 & 2

Robert Cantley
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Starting with a brief non-technical summary of some of the more spectacular *Nepenthes* of the Philippines, specifically those species found on the island of Mindanao and the Visayas, the talk will then focus on the findings of several expeditions to these areas. The aim of these expeditions was to attempt rediscovery of some "lost" species of *Nepenthes* but the weary travellers ended up stumbling across some possible new species in the process.

Four Investigations of Carnivorous Plants and Triggerplants

Foy K., McDermott M., McMahon M.E., Weisbrod A., Darnowski D.W.
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A laboratory for basic and applied research on carnivorous and subcarnivorous plants (various genera and families) and on triggerplants and their relatives (*Stylidium*, *Levenhookia*, others; Stylidiaceae)

Foy K., McDermott M., McMahon M.E., Weisbrod A., Darnowski D.W.
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(The following abstract describes both presentations noted above)

Several projects dealing with carnivorous and subcarnivorous plants and with triggerplants and their relatives, both from a basic and from an applied standpoint, continue at a new laboratory at Washington College in Maryland. The projects usually deal with both groups of plants, thus the inclusion of triggerplants for this abstract.

1) Using basic approaches, KF and DWD have begun a study of the role of the actin cytoskeleton in the bending/nonbending of stalked glands from various carnivorous genera, concentrating on actin and on the actin monomer-binding protein profilin.

2) In order to better understand the biochemical function of carnivorous leaves a)on a fine scale, MM and DWD have begun work with specialized electrophoresis cells which, it is hoped, will allow resolution of proteins in dilute samples, such as those from very small samples of leaf tissue, at the gel and Western blot levels, and b)on more gross scale they have started work on an improved field for plant carnivory to cover lipids, nucleic acids, and carbohydrates, as well as proteins. The apparati are designed to perform SDSPAGE, IEF, and two-dimensional protein resolution.

3) On the applied side MEM and DWD are exploring a propagation system using the hormone/agricultural chemical TDZ, a cytokinin. This method may be general, though its use at the moment is being tested for the rapid and season-independent propagation of pygmy *Drosera* spp. and *Stylidium* spp.

4)AW and DWD are considering the effect of smoke on the germination of Western Australian carnivorous plants and triggerplants. Presently, concentration is on *Stylidium calcaratum*, *S. graminifolium*, *Levenhookia pusilla*, and *Drosera erythrorhiza* subsp. *erthyrorhiza*, and on the use of a novel small scale device for the production of a smoke extract which can be used in tissue culture germination of such seeds.

Students Shauna Bolden, Leora-Leigh Ramiro, and Briana Neal are also participating in various aspects.

Triphyophyllum peltatum (Dioncophyllaceae)—Cultivating a Clandestine Carnivore

Jan Schlauer[1], Heiko Rischer[1], Kristina Wolf[1], Gerhard Bringmann[1], Helmut Fleischmann[2], Uwe Buschbom[2], Martin Duschek[2], Andreas Kreiner[2], Friedrich Thiele[2]
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The systematics, life history, natural environment, and the carnivory of the rare tropical West African high forest liana *Triphyophyllum peltatum* are presented. Experience with cultivating *T. peltatum* in the greenhouse and *in vitro* at the University of Würzburg (Bringmann *et al.*, 1999) is shared. For the first time it was possible to study the whole life cycle of this species in cultivation. Carnivory was found not to be a prerequisite to reach full maturity or to produce flowers and seeds. The facultative carnivory of *T. peltatum* is an intriguing aspect of carnivorous plant evolution within Nepenthales, a flowering plant order that contains four different carnivorous plant families, *viz.* Nepenthaceae, Droseraceae, Drosophyllaceae, and Dioncophyllaceae *p.p.*, together with non-carnivorous ones, including Polygonaceae, Plumbaginaceae, Ancistrocladaceae, and Dioncophyllaceae *p.p.*).

The secondary metabolism of *T. peltatum* is as unusual as the plant itself. Besides plumbagin and similar quinones, which are characteristic for Nepenthales, the plant contains naphthylisoquinoline alkaloids (Bringmann *et al.*, 1998), which are so far known only from Dioncophyllaceae and Ancistrocladaceae. Biosynthetic and chemotaxonomical aspects of these secondary metabolites are discussed.

References

Bringmann, G., Aké Assi, L., François, G., Schlauer, J. (1998) The Alkaloids of *Triphyophyllum peltatum* (Dioncophyllaceae). Chimia 52: 18-28.

Bringmann, G., Schlauer, J., Wolf, K., Rischer, H., Buschbom, U., Kreiner, A., Thiele, F., Duschek, M., Aké Assi, L. (1999) Cultivation of *Triphyophyllum peltatum* (Dioncophyllaceae), the Part-Time Carnivorous Plant. Carniv. Pl. Newslett. 28: 7-13.

A New Carnivorous Plant Course for Young People

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A new course on carnivorous plants is described. The course is taught annually as part of an enrichment program for students age seven through nine. The course is based upon the Bloodthirsty Plant book series by Gareth Stevens Publishing. Beyond the purely educational aspects, the course emphasizes fun and incorporates numerous craft activities.

Inspired by Michael Szeszes' work, I began to teach a course for young people on carnivorous plants. My course is now offered annually through The Young Scholars Program at the University of Wisconsin-Whitewater. The Young Scholars Program is an enrichment program for area grade school students and is offered cooperatively through the UW-W. Continuing Education Services and the Area Gifted and Talented Network. My course is geared towards students younger than Michael Szeszes', and incorporates my interests in crafts. I have developed a 16 page workbook to augment the course.

My course (entitled The Weird, Wild, Wacky and Wonderful World of Carnivorous Plants) is a six Saturday, two hour per day class for seven through nine year old students (U.S.A. grades second through fourth). On each of the first five days, a different carnivorous plant group is introduced: sundews, butterworts, Venus flytraps and waterwheels, pitcher plants, then bladderworts. The two hour class is roughly divided into halves: the "educational" hour, and the "creative expression" hour. The sixth day is a festive review and inspirational send off to further learning.

The educational hour begins with a story about the carnivorous plant topic of the day using the "Bloodthirsty Plant" book series by the Gareth Stevens Publishing company of Milwaukee, Wisconsin. This series consists of six books, each a 24 page documentation of a different carnivorous plant group. These books are the stepping-off point for observations, discussion and questions. After reading the book to the class, live examples of the plant genus of the week are examined. Class participants are encouraged to TOUCH the sticky mucilage, SNIFF for sweet scents, and LOOK for trigger hairs, downward-pointing hairs and insect remains.

Next we examine how the plants work. Winged fruit flies are released into a bell jar with the various carnivorous plants. For the tiny bladderwort, a video camera attached to a dissecting microscope is used to observe live protozoa swimming among the bladder traps. After an informal discussion of what we have learned, we sit down to our workbooks and together answer key questions about our genera of the day. Thus concludes the educational half.

The creative expression half, while a great deal of fun, actually includes many educational aspects. Students piece together jigsaw puzzles that contain pitcher plants in their habitats then answer habitat riddles. Sundews are grown from seed, and butterworts from leaf cuttings and division. We discuss winter treatment, and why it is so important to not take plants from

the wild. We learn how to obtain tried and true, easy-to-grow varieties.

Students model sundews from pipe cleaners, mold pitcher plants in clay, and fashion a Venus flytrap puppet out of a paper plate. They construct an origami butterfly for the Venus Flytrap puppet to eat. They build a butterwort out of green bread, and shake green-dyed cream to make the buttery mucilage. They link hands to form a human bladderwort trap and act out the capture of classmate prey. Then they create their own stories and pictures of their experiences and record them, with their thoughts, in their notebooks.

I forward this work to contribute to the discussion, began by Michael Szesze, on the use of carnivorous plants in science education. I have developed and have now described a very hands-on, informative, yet fun course on carnivorous plants that is geared towards students aged seven through nine.

References

Szesze, M. (1997) An Activity Book for Carnivorous Plants. 255 pages. P.O. Box 89; Stamford, CT 06904, USA

Gentle, V. (1996) Bloodthirsty Plant Series. Gareth Stevens Publishing, 1555 North RiverCenter Drive, Suite 201; Milwaukee, WI 53212, USA
Bladderworts: Trapdoors to Oblivion ISBN 0-8368-1654-4
Butterworts: Greasy Cups of Death ISBN: 0-8368-1655-2
Pitcher Plants: Slippery Pits of No Escape ISBN: 0-8368-1657-9
Sundews: A Sweet and Sticky Death ISBN: 0-8368-1658-7
Venus Fly Traps and Waterwheels: Spring Traps of the Plant World ISBN: 0-8368-1659-5
Carnivorous Mushrooms: Lassoing Their Prey? ISBN: 0-8368-1656-0

Golembiewski, T.A. (2000) The Weird, Wild, Wacky and Wonderful World of Carnivorous Plants. 16 pages. University of Wisconsin-Whitewater, Department of Biological Sciences, 800 West Main Street, Whitewater, WI 53190, USA

Carnivorous Plants of the West

J. Hawkeye Rondeau
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I will identify several common species of carnivorous plants via slides/individual samples, and discuss their relevance in the Western US and Canada. Included in this presentation will be the relative abundance, distribution, life history, or other pertinent information for each species. Special emphasis will be placed on the taxonomy, distribution, and status of current research on *Pinguicula macroceras*, *Sarracenia purpurea*, and *Utricularia ochroleuca*.

The Lost World of Venezuela: Some Observations on Carnivorous Plants in the Guyana Highlands

Andreas Wistuba, Joachim Nerz
Germany

In the Southern part of Venezuela there is one of the most remote and bizarre landscapes in the world: the Guyana highland with about 120 flat-topped table-mountains or tepuys (Indian: house of gods). These are spectacular sandstone-mountains with mostly vertical walls and vast plateaus on their tops. Due to the isolation of each mountain, there is a very high degree of endemism. The ground is very poor and sandy, useless for agriculture. Therefore the whole area remains nearly undisturbed until today. Because of the difficulties to travel in this region the whole area remained nearly unexplored until very recently, and now there are still "white spots" on the maps of this area! One of the most prominent early naturalists who visited the lowlands of the Orinoco/Casiquare-river was the German Alexander von Humboldt. A further important early expedition was undertaken by another German naturalist, Schomburgk. He was the first one to travel extensively in the savannahs of the Guyana Highlands. He was able to get to the foot of the famous Mt. Roraima. For the first time he found there a new member of the Sarraceniaceae: *Heliamphora nutans*. But until that time, nobody had ever been on the top of these mystery mountains. In 1884, the British naturalist Evard F. Im Thurn was able, to climb Mt. Roraima and he was very impressed by the unique plateau. Tate reached the top of Mt. Duida with about 70 helpers in the year 1928. Here he found the second species of *Heliamphora*, which was named later in honour of him: *Heliamphora tatei*. Extensive fieldwork was undertaken by botanists of the Botanic Gardens of New York and Missouri in the fifities and sixties of the 20th century. Many new tepuys were visited and explored, mostly by helicopters and many new species were described by Julian Steyermark, Bassett Maguire, John Wurdack and many other botanists.

Due to the poor soil, the area is one of the richest carnivorous plant habitats in the world, with many spectacular members of the genera *Heliamphora*, *Brocchinia*, *Drosera*, *Genlisea* and *Utricularia*! In 1988 and 1999, we visited the area and our main interest was to find some of the lesser known *Heliamphora* species, including *Heliamphora ionasii*, the most impressive *Heliamphora* species. Nearly nothing was known about this species before. It was just collected once by the American botanists (Maguire et al.). Beside this, we did some explorations at Roraima-Tepuy and Kukenan-Tepuy and in the lowlands of the Guyana highlands. The intention of the second expedition was to reach Cerro de la Neblina, the most remote of all tepuys, hidden deep in the Amazonian jungle. Due to its remoteness, it was discovered in 1956, just 40 years ago. From this time,

all Brazilian geographic books had to be corrected. With its altitude of 3000 m, it is now the highest mountain of Brazil. The aim of this expedition was to find one of the *Heliamphora* species with long pitchers: *Heliamphora tatei neblinae*. The results of these expeditions will be presented in this talk.

Reference
Flora of the Venezuelan Highlands, Volume I, 1995, General editors: Julian A. Steyermark, Paul E. Berry, Bruce K. Holst, Timber Press.

A Carnivorous Plant Tour of New Caledonia, Australia and South Africa

Robert Gibson
PO Box 1330 • Dubbo, NSW, 2830 • Australia

Slides and observations on a selection of carnivorous plant species in New Caledonia, Australia and South Africa are presented. Habitat attributes in these areas are outlined, which reveals common aspects of soil characteristics, underlying geology, plant associations and communities, and plant-animal interactions between these widely separated locations. Philosophical ideas on the evolutionary development of these populations follow. The final part of the talk details suggestions on cultivation of a selection of species based on field observations.

The Invaders vs. The Carnivores: Invasive Species and Carnivorous Plants

Barry Meyers-Rice
Wildland Invasive Species Program • The Nature Conservancy • University of California • Davis, CA 95616 • USA

The second most important cause for species extinction (after habitat destruction) is the introduction of exotic species. The most well-known are exotic animals—-horror stories of brown tree snakes, zebra mussels, and arthropod-related tree diseases abound. Less well known are the dangers from exotic plant species. In national surveys in 1995 and 1998, land managers for The Nature Conservancy listed the issue of exotic species as being one the their main concerns. Exotic species degrade habitat, displace natives, and can leach a wildland of its natural value. A large number of preserves stewarded by The Nature Conservancy are freshwater wetland sites and harbor carnivorous plant species, including *Sarracenia alabamensis* and *Sarracenia rubra* subsp. *jonesii*. Wildland weeds are significant issues at these, and other preserves.

In the last few decades, The Nature Conservancy has changed its strat-

egy in land protection. Instead of selecting key sites to protect specific organisms, the perspective is now on saving entire "functional landscapes," where the natural processes of fire, flooding, grazing, etc., are intact. Yet even on these scales, wildland weeds are significant threats to ecosystems.

This talk will review some of The Nature Conservancy's carnivorous plant reserves (and especially how they are being affected by exotic species). Efforts to control the exotic species will be discussed. Finally, a few aspects of carnivorous plants as exotic species themselves will be mentioned.

Mechanisms of Trap Closure in *Dionaea muscipula*

Laurent Legendre
University of Reims • France

Leaf movement is one of the most intriguing feature of plant sciences. A large body of research has now tried to unveil the biochemical mechanisms behind the rapid closure of the Venus fly trap. Some of these advances will be described and illustrated with experiments conducted on live plants. The evolutionary relationship between this mechanism of leaf movement and the one of other members of the carnivorous family, Droseraceae, will then be explained.

Touching one of the 6 hairs present on the upper trap surface sensitizes all of them to initiate the rapid closure of the trap when touched a second time. Even though this double touch mechanism is required to prevent artificial closure by rain drops or plant debris pushed by the wind, the nature of the sensitization signal that rapidly travels through the whole trap is still speculative. Surprisingly, the Venus fly trap seems to have a very short memory of the first touch so that many insects could get by if they knew it. An increasing number of touches is indeed required to obtain full trap closure when the time between the two touches is increased.

Hurting a trigger hair generates a heavy mechanical stress at its base, a hinge region that is slender and more flexible than the rest of the hair. Under this mechanical stress, the cells at this hinge region liberate a chemical signal that will travel through the trap at high speed (10 cm/s) without losing intensity. When reaching the cells at the outer surface of the trap it will force them to grow rapidly. As the size of the cells on the inner surface do not increase their size, the trap will close, the curvature of the trap being greater at its edge. Even though the full nature of the traveling signal is not known, it has been suggested that ions such as chloride and calcium are involved. As these are charged particles, their movement across cellular membranes generates a depolarization signal which, when moving from one part of the trap to the next, resembles an electrical current. Interestingly, the cells at the hinge region that initiates this signal contain cellular structures which are unique to the plant kingdom but are found in animal muscle cells. In spite of this convergent evolution feature, plant and

animal structures work on opposite ways as one responds mechanically to an electrical nerve signal while the other one produces an electrical signal under mechanical stimulation

The differential growth of the outer cell layers is obtained via an acidification outside their cells (acid growth theory). This acidification loosens their cell wall fibers so that the cells will elongate due to their internal turgor pressure. This phenomenon is irreversible and the reopening of the trap occurs via the elongation of the cell layer on the inner side of the trap to equal the one of the external surface. Thus, a trap that has already closed and reopened is larger. Moreover, the elongation of the cell wall fibers cannot repeat forever (until they are parallel) and a trap can only work 3 times in its life. The fast closure movement of the trap is followed by a slow movement induced by the degradation products that leach from the early digestion of the prey. This second closure mechanism will allow the trap edges to come into contact with each other and seal the trap to facilitate digestion. Remarkably, the pressure exerted by the two trap lobes on each other varies according to a circadian rhythm and is maximum each day (starting two days after prey capture) early in the afternoon.

Carnivorous Plants of New Caledonia

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New Caledonia is a small French territory located in the southern pacific ocean, 1500 km east of the Australian coast. It comprises a large number of tropical islands, but only the main one (called "la grande terre" over there) hosts carnivorous plants. More precisely, most carnivorous plants thrive in the southern tip of this island, in or around a large bog called "la plaine des lacs". Five taxa have been described: *Nepenthes vieillardii*, *Drosera neocaledonica*, *Utricularia uliginosa*, *U. gibba* and *U. novae-zelandiae*. Even though I was unable to witness the presence of the latter two *Utricularia* species or confirm their existence with the specimens stored at the herbarium in Noumea (capital city) or with the ones local botanists showed me, I was lucky enough to make several interesting observations on the three other carnivorous taxa. These observations stem from the visit of several hundreds of stations of each species three years in a row, each time around Christmas eve, in the middle of the summer, just before the start of the rain season.

N. vieillardii grows from sea level up to an elevation of 500 m. It favors open, sunny and well drained areas. It clearly benefits from the passage of cyclones, mining activity, road works and deforestation thanks to its carnivorous habit and its tendrils which do not allow it to climb on the surrounding vegetation but rather attach to it so that its liana do not break off under high wind or rain. Under sunny conditions, the plants bloom extensively, and develop light green and thin leaf blades, each of which produce a pitcher. The slightest shade will, however, slow growth and force the

plants to stop flowering. Such plants will produce leaves that are 4 to 5 times longer, dark green, with thick leaf blades and no pitcher. This *Nepenthes* species is a case study for carnivorous plants enthusiasts as it develops 4 types of easily distinguishable pitchers: juvenile, lower, intermediate and higher. The pitchers exhibit a large color variation. Even though lower or older pitchers are always more red than higher or younger ones, it has become clear to me that different clones thrive on this island. Plants on the west coast (Mont Koghi) are all in the greens and reds while the pitchers of some plants on the southern locations (port Boise) are dark purple or all green with a black peristome, and plants on the east coast (Prony) have yellow-brown pitchers. It has also become apparent to me that, on the west coast, some plants only have all green pitchers while some see their pitchers go from green to red as they age or when they are located lower on the branch. Even though both populations often live at the same spot, no intermediate coloration can be seen, red plants are always more numerous and the presence of sun or shade does not seem to influence coloration.

But what is more intriguing is that the flowers of these plants also exhibit color variations. Male and female flowers can indeed be either green or red independently of the color of the pitchers. While dissecting some pitchers, I discovered that lower pitchers eat more creeping insects while higher pitchers preferably catch flying ones. Many live mosquito larvae could be seen floating in the pitcher fluid of lower and sometimes intermediate pitchers. A still unknown solitary large caterpillar with funny-looking antennas was also found to be living at the bottom of the fluid of the lower/intermediate pitchers.

The base of the stems of this *Nepenthes* species is visibly swollen all the way down to 10 cm below the ground and may serve as a water storage organ to survive through the dry season, a period during which the plants stop growing This rest period is also observed when the plants are cultivated all year long under warm and humid conditions. In cultivation, the top portion (ca. 10 cm) of the root only starts to thicken six months after seed germination.

D. neocaledonica is endemic to New Caledonia. Contrary to *N. vieillardii*, it displays no color or shape variation. It grows at elevations comprised between 100 and 500 m close to fresh water lakes and thus may be covered by water during the rainy season and stay bone-dry during the dry season. It prefers flat, sunny places and benefits from seasonal fires that clear its habitat from the bog weed *Xyris pancheri*. Even though many seedlings could be seen, the germination of seeds seems to be a problem in cultivation. It, however, propagates well via leaf cuttings.

U. uliginosa is usually found below the water surface (even at more than one meter below the water surface) and sometimes at the water edge. Flowers will not open unless they are above the water. They display a large panel of color variation from pure white to pink and blue. These color differences are retained under cultivation. The leaves are lanceolate and vary in length from a couple millimeters all the way up to 10 cm, a character

which is lost under cultivation. I still do not know which factor controls the final size of the leaves. These will be whiter in full sun and greener in shaded areas. Some of the longest leaves form segments at the junction of which new leaves or flower stems may develop. The high leaf variation of this species as well as the fact that entire clumps can be unearthed and cleaned during heavy rain falls is, in my opinion, the origin of many misidentifications on New Caledonian *Utricularia*.

Even though carnivorous plants are common in New Caledonia, the future of all *Drosera* and *Utricularia* is threatened by the construction of a chemical plant to treat Nickel right at the center of this unique bog where most of them live. Let us hope that many clones will soon go into cultivation to preserve the rich genetic diversity present on this island.

The conservation of Three Federally Endangered *Sarracenia* by the Atlanta Botanical Garden

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As part of its mission statement and Conservation Program, the Atlanta Botanical Garden (ABG) is a key player in the monitoring and restoration of the low nutrient, acidic wetland habitats of the genus *Sarracenia* (pitcher plants) in the southeastern USA. Many pitcher plant communities have now been drained or reduced to small, fragmented plots of land surrounded by urbanisation and agriculture and under threat from invasive species, use of herbicides, over-collection and harvesting. There has also been a dramatic reduction in or complete elimination of many of the natural processes that maintain these habitats, including beaver activity and fire. ABG has concentrated its efforts on those *Sarracenia* listed as Federally Endangered under the USA Endangered Species Act (1973)—*S. alabamensis* in Alabama (12 populations), *S.rubra* subsp. *jonesii* in North and South Carolina (9 populations), and *S. oreophila* in Alabama, Georgia and North Carolina (35 populations).

Under contract to the US Fish and Wildlife Service and TNC on a number of projects, ABG focuses on establishing a good working relationship with state, federal and, in particular, private landowners, especially given that the majority of extant habitat is now in private hands. ABG has developed a number of low-cost, low-tech restoration techniques to restore *Sarracenia* habitat and, where possible, natural processes are reinstated (use of winter/summer burns, hydrology), and material available at the site is used. ABG has also developed educational programmes and techniques (e.g. building carnivorous plant bogs for schools), that use *Sarracenia* and other carnivorous plant taxa to highlight the loss of wetlands world-wide.

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Pollination and Reproductive Ecology of Three Lowland Tropical Pitcher Plants (*Nepenthes*) and Their Hybrids

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Tropical pitcher plants have been the subject of substantial scientific scrutiny for their prey digestion (Frazier, 2000), but other aspects of their biology, particularly their reproductive ecology have garnered much less attention. Species in the genus *Nepenthes* are interfertile under greenhouse conditions, yet in the field demonstrate a high degree of sympatry. This suggests that differences in reproductive strategies may play an important role in reducing hybridization and maintaining species distinction under natural conditions. I studied the three species of *Nepenthes* present in Johore, Malaysia and Singapore, *N. gracilis*, *N. ampullaria* and *N. rafflesiana*, to determine if there are significant differences among species in phenology, floral and nectar characteristics and pollinators. I also addressed the fitness of naturally occuring hybrids. Differences in flowering period represents at best a partial barrier to cross-pollination among species. Each species has three flowering periods between January and July, but the timing of these episodes is offset among species such that at any given time one, two or all three species are in flower. Floral presentation differs among species in such characters as the number of flowers per inflorescence, flower size and color and sepal shape (Frazier, in press). *N. ampullaria* flowers present pollen during the day, while the other two species open their flowers in the evening. Nectar is produced nocturnally in all three species, but they differ in sugar composition and quantity of nectar produced. These differences suggest the species are adapted to attract different suites of pollinators. All species are pollinated by moths and small Diptera, but to differing degrees. *N. rafflesiana* is pollinated almost entirely by moths and all of its pollination is nocturnal. *N. gracilis* is pollinated almost equally by moths and small Diptera at night and also by wasps during the night and day. By day, *N. ampullaria* flowers have a foul odour and are pollinated by large flies, wasps and butterflies. The flowers produce a sweet odour at night and are then visited by moths. These differences are significant between species, but still not sufficient to constitute a complete barrier to cross-pollination.

Low hybrid fitness may also act as a barrier to gene flow between the parent species. I found that hybrids in the wild abort significantly more flowers, produce fewer seeds per inflorescence and have a lower efficiency of seed production (seeds produced per gram of inflorescence) than the parent taxa. Nevertheless, some hybrid inflorescences demonstrated zero flower abortion and produced seed quantities on par with the parent taxa, suggesting that ecological phenomena and not intrinsic sterility barriers

are the main factors limiting hybrid fitness.

My results show that many factors interact to limit, but not preclude hybrid production and that lower hybrid fitness comprises a further, though incomplete barrier to gene flow. I suggest that the combination of such partial barriers allows sympatric species to retain species distinction without intrinsic sterility barriers, although some degree of interspecific gene flow is still likely.

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Recent *Nepenthes* Discoveries

Ch'ien Lee
Malesiana Tropicals • Kuching • Sarawak

(no abstract available)

Secondary Metabolism of *Triphyophyllum peltatum* (Dioncophyllaceae)

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The family Dioncophyllaceae comprises the three monotypic genera *Dioncophyllum*, *Habropetalum* and *Triphyophyllum*. All of them are lianas growing in the tropical forests of West Africa and although they have morphological features like for example the unique hooked leaves and the seeds with their round wings in common, the at least 'part-time carnivorous' behaviour is so far only reported from *Triphyophyllum peltatum* (Bringmann *et al.*, 1996).

This contribution is focused on the secondary metabolism of *Triphyophyllum*. It serves as an excellent example because the prominent naphthylisoquinoline alkaloids, which exhibit a broad range of biological activities (*e.g.* Boyd *et al.*, 1994; François *et al.*, 1997), are only found in the families Dioncophyllaceae and the closely related Ancistrocladaceae. These alkaloids are chemically characterized by their biaryl axis, which connects the two parts (isoquinoline and naphthoquinone) of each molecule (Bringmann and Pokorny, 1995). Up to now there are about 16 naphthylisoquinolines known from *T. peltatum*. In addition to the isolation and

structural elucidation, we recently proved their unprecedented biosynthetic origin from acetate units by feeding callus cultures with 13C2-labelled sodium acetate and analyzing the metabolites formed, by NMR-techniques (Bringmann *et al.*, 1999).

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The Effects of Light on a Carnivorous Plant, *Drosera capillaris*.

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Carnivorous plants are recognized as being restricted to habitats with high light environments. However, the micro-site condition of an individual plant may change over its lifetime. Although, there are studies on how variations in light quality and quantity affect non-carnivorous plants, there has been little work done on carnivorous plants. In the current study, we manipulated photosynthetic photo flux density (PPFD) and spectral quality (reduction of R: FR ratio) under shade house conditions and documented the development and morphology of the carnivorous leaves of *Drosera capillaris*. The results of this study provide insight on how a carnivorous plant may maintain a balance between photosynthetic and carnivorous characters under an uncertain or varying micro-site light environmental.